



Wrought steels for use at elevated temperatures in engines

Aciers corroyés pour usage à températures élevées dans les moteurs

At its meeting in December 1967, ISO/TC 17/SC 4, *Heat-treatable and alloy steels*, agreed to deal with the standardization of creep-resisting steels. ISO/TC 17/SC 4 has studied this item since 1969. In the course of time, five draft proposals were discussed and as a result of this it became obvious that in this field to a considerable extent proprietary specifications of more or less national importance are still applied that a rationalization or harmonization of these specifications is still premature, and that even for types used in several countries the specifications in the various countries differ considerably especially with respect to elevated temperature data.

Under these circumstances, it seemed reasonable to forego publication of an International Standard. However, the agreements achieved during the various negotiations will be made available to everybody interested in this field, in the form of a Technical Report.

To facilitate subsequent publication of an International Standard, data for the amendment of this Technical Report should be sent to the ISO Central Secretariat.

1 Scope

1.1 This Technical Report covers technical delivery requirements and technical information for wrought steels supplied for parts such as bolts, blades, discs or casings in stationary or non-stationary turbines required to withstand relatively high mechanical stresses at elevated temperatures (above about 400 °C) and additionally corrosive attack by hot gases.

NOTE — Other steel types exist which are used mainly for large engine parts; these steel types are not covered by this Technical Report, since they are sold mainly to proprietor specifications only.

1.2 Unless otherwise stated, this Technical Report is applicable to blooms, billets, bars, forgings, strip, sheet, plates and wire in the delivery conditions given in 4.2.

1.3 International Standards exist for heat-resisting steels (see ISO 4955)¹⁾, valve steels for internal combustion engines (see ISO 683/15), and steels for use on and with pressure vessels and boilers (see ISO 2604/1 to 6).

¹⁾ At present at the stage of draft.

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2 References

ISO/R 79, *Brinell hardness test for steel*.

ISO/R 81, *Vickers hardness test for steel (load 5 to 100 kgf)*.

ISO 82, *Steel-Tensile testing*.

ISO 86, *Steel-Tensile testing of sheet and strip less than 3 mm and not less than 0,5 mm thick*.

ISO 89, *Steel-Tensile testing of wire*.

ISO 148, *Steel-Charpy impact test (V-notch)*.¹⁾

ISO/R 377, *Selection and preparation of samples and test pieces for wrought steel*.

ISO 404, *Steel and steel products — General technical delivery requirements*.

ISO/R 783, *Mechanical testing of steel at elevated temperatures — Determination of lower yield stress and proof stress and proving test*.

3 Ordering

3.1 The purchaser shall state in his enquiry and order

- a) the steel type (see table 2);
- b) the product form and the dimensions and tolerances of the product (see 4.8);
- c) the treatment condition including surface condition (see 4.2);
- d) the quantity to be delivered;
- e) the requirement class (see table 1);
- f) the required type of document (see 5.6).

3.2 Certain options in ordering are permitted by this Technical Report and the purchaser may also state in his enquiry and order his related requirements as shown below.

- a) whether a product analysis is required (see 4.4.2);
- b) whether the mechanical properties for other dimensions than according to table 4 are to be specified;
- c) in cases in which tensile and impact properties are to be verified on reference test pieces and in cases in which more than one heat treatment is indicated in tables 4 and 5 for the type of steel concerned, the heat treatment to be applied (see 5.3.3.3);
- d) in cases in which minimum proof stress at elevated temperatures is to be verified, the testing temperature selected from table 6 (see 5.4.5);
- e) the machining allowances (see 4.7.2).

3.3 The relevant clause of ISO 404 is valid.

4 Requirements

4.1 Manufacture of the steel and of the product

Unless otherwise agreed in the order, the processes used in making the steel and the product are at the manufacturer's discretion. When he so requests, the user shall be informed what steelmaking process is being used.

¹⁾ At present at the stage of draft. (Revision of ISO/R 148-1960.)

4.2 Treatment condition at the time of delivery

4.2.1 The surface and heat-treatment condition at the time of delivery is to be agreed at the time of enquiry and order.

4.2.2 Products which are not determined for further hot- or cold-forming operations are usually delivered in the heat-treatment conditions indicated in table 5.

Products intended for further forming operations are usually delivered in the following conditions :

- a) in the case of martensitic steels: "annealed on a hardness ≤ 270 HB";
- b) in the case of austenitic steels: "treated for further forming operations".

4.2.3 The steels are delivered by casts.

4.3 Requirement classes¹⁾

The steels covered by this Technical Report shall be ordered and delivered in accordance with one of the requirement classes given in table 1.

4.4 Chemical composition

4.4.1 The chemical composition of the steels, as given by the cast analysis, shall be in accordance with the specifications in table 2. The cast analysis, if called for in the order, shall be provided by the manufacturer.

4.4.2 The permissible deviations between the values specified in table 2 and the product analysis are given in table 3. If a product analysis is required by the purchaser, this shall be stated in the enquiry and order.

4.5 Mechanical properties

4.5.1 When ordering according to the requirement class 1a, 9 or 10 and according to a heat-treatment condition given in table 5, the hardness values specified in table 4 apply for the product in the delivery condition.

4.5.2 When ordering according to the requirement class 5 or 6 and according to a heat-treatment condition given in table 5, the tensile and impact properties specified in table 4 apply for the product in the delivery condition.

4.5.3 When ordering according to requirement class 7, 8, 9 or 10, the tensile and impact properties specified in table 4 apply for reference test pieces which were prepared in accordance with 5.3.3.3.

4.5.4 When ordering steels according to requirement class 6, 8 or 10, the elevated temperature yield or proof stress values specified in table 6 apply either for a test piece in the delivery condition (requirement class 6) or for a reference test piece (requirement class 8 or 10) (see 5.3.3.4).

4.6 Further material characteristics

There are some further material characteristics for which however it is impossible at the time being to formulate clear requirements. As far as appropriate and possible, annex A gives technical informations for these characteristics.

4.7 Surface quality

4.7.1 All products shall have a workmanlike finish and shall be clean and free from surface imperfections likely to have an adverse effect.

¹⁾ In former International Standards prepared by TC 17/SC 4, the term "type of condition of delivery" was used instead of "requirement class". It was replaced in order to avoid confusion with the term "delivery condition", which is often used for the treatment condition of the steel at the time of delivery.

4.7.2 Hot-rolled, forged, cold-drawn or rough-machined products shall be delivered with a machining allowance for the removal, by machining or grinding of

- a) surface decarburization, and
- b) surface imperfections.

As long as no International Standard for the machining allowances of creep-resisting steels is available, the allowances shall be agreed at the time of enquiry and order.

4.8 Dimensions and tolerances

4.8.1 The products shall, if possible, be ordered and delivered in accordance with existing International Standards for dimensions and tolerances (see list in annex B). The ordered dimensions must, where applicable, include the minimum machining allowances (see 4.7.2) and the undersize tolerance.

4.8.2 If corresponding International Standards for dimensions and tolerances are not yet available or if the tolerances given in the corresponding International Standard are not applicable for creep-resisting steels, then the dimensions and tolerances shall be agreed at the time of enquiry and order.

5 Testing

5.1 General

5.1.1 For all requirement classes, acceptance tests can be agreed.

5.1.2 If acceptance tests have been agreed the general conditions of ISO 404 regarding

- the place of acceptance,
- the submission for inspection,
- the rights of the inspector,
- the acceptance,

and, furthermore, the conditions given in 5.2 to 5.6 (as far as these are applicable according to the ordered requirement class) are to be observed.

5.2 Test unit and number of sample products and tests

5.2.1 Chemical composition

The cast analysis, if called for in the order, shall be provided by the manufacturer. If a product analysis is required by the purchaser, and if not otherwise agreed at the time of enquiry and order, one sample product shall be taken from each cast.

5.2.2 Mechanical properties

If, according to the ordered requirement class (see table 1) and the required type of document (see 5.6 and 5.1.2) the mechanical properties are to be verified, then the indications in table 7 apply for the test unit and the number of sample products and tests.

5.3 Selection and preparation of samples and test pieces

5.3.1 General

The general conditions given in ISO/R 377 for the selection and the preparation of samples and test pieces shall apply.

5.3.2 Product analysis

For product analysis, the selection and preparation of samples shall be carried out in conformity with the requirements of ISO/R 377.

5.3.3 Mechanical properties

5.3.3.1 For the hardness test, the surface of the sample product or of a test piece taken from the sample product in the delivery condition shall be prepared in accordance with the requirements in ISO/R 79 (Brinell hardness) or ISO/R 81 (Vickers hardness).

5.3.3.2 If the tensile and impact properties at room temperature are to be verified on test pieces in the delivery condition (requirement classes 5 and 6), the samples and test pieces shall be taken from the delivery in accordance with figure 1a or 1b, and shall be prepared in accordance with the International Standards mentioned in figures 1a or 1b.

5.3.3.3 If the tensile and impact properties at room temperature are to be verified on reference test pieces (requirement classes 7, 8, 9 or 10), the test samples shall be taken from the delivery in accordance with figure 1a or 1b and shall be heat treated in accordance with the heat-treatment conditions indicated in table 5 for the relevant steel. If in this table more than one heat treatment is indicated for the steel concerned, the treatment to be applied shall be agreed at the time of enquiry and order.

After the heat-treatment of the samples, the test pieces shall be taken and prepared in accordance with the indications in figure 1a or 1b.

5.3.3.4 If the yield or proof stress at elevated temperatures as specified in table 6 is to be verified on test pieces in the delivery condition (requirement class 6) or on reference test pieces (requirement classes 8 or 10), a test piece according to ISO/R 783 shall be taken under conditions corresponding to those specified for taking the test pieces for the tensile tests at room temperature (see 5.3.3.2 and 5.3.3.3).

5.4 Test methods

5.4.1 Chemical analysis

In cases of dispute, the methods used for the chemical analysis shall be those established by the relevant International Standards. If no International Standards are available, the methods shall be agreed upon at the time of enquiry and order.

5.4.2 The Brinell hardness test shall be made in accordance with ISO/R 79. The Vickers hardness test shall be made in accordance with ISO/R 81.

5.4.3 The tensile test at room temperature shall be made in accordance with the International Standards according to which the test pieces are to be prepared (see figures 1a and b).

5.4.4 The impact test shall be made in accordance with ISO 148 (V-notch). Unless otherwise specified at the time of enquiry and order, the impact value shall be determined by the arithmetic average of three test results.

5.4.5 The yield or proof stress at elevated temperature shall be determined in accordance with ISO/R 783 at a temperature selected from table 6 and agreed at the time of enquiry and order.

5.5 Retests

For retests, ISO 404 is valid.

5.6 Certification of the tests

ISO 404 is valid, acceptable documents being one of the following

- statement of compliance with the order;
- report based on quality control;
- works certificate;
- test certificate;
- certificate of acceptance.

6 Rectification, defects and reclaiming

If not otherwise stated in the foregoing, the conditions given in ISO 404 are valid for

- surface defects;
- rectification;
- internal defects;
- dimensional tolerances;
- reclaiming.